

What is claimed is:

1. A circuit board assembly comprising:

a circuit board including a plurality of conductive circuit traces extending from a plurality of contact surfaces;

a substrate having a plurality of contact terminals, individually connected to the contact surfaces of the circuit board by solidifying molten solder, an outer surface facing away from the circuit board, including a central portion and an annular portion extending around the central portion, and a plurality of contact surfaces, extending along the central portion of the outer surface of the substrate, electrically connected within the substrate to the plurality of contact terminals of the substrate;

a circuit chip extending adjacent the central portion of the outer surface of the substrate, wherein the circuit chip has a plurality of contact terminals, individually connected to the contact surfaces of the substrate by solidifying molten solder, and an outer surface;

a heat sink extending outwardly from the circuit chip and the substrate, wherein the heat sink includes an inner surface having a central portion extending adjacent the outer surface of the circuit chip and an annular portion extending outward from the central portion;

a layer of thermally conductive material extending between the external surface of the circuit chip and the central portion of the inner surface of the heat sink; and

a cured layer of cure shrinkable adhesive extending between the annular portion of the outer surface of the substrate and the annular portion of the inner surface of the heat sink to hold the heat sink in place over the substrate and to hold the layer of thermally conductive material in compression.

1        2.    The circuit board assembly of claim 1, additionally comprising a  
2        compression limiting structure extending between the annular portion of the outer  
3        surface of the substrate and the annular portion of the inner surface of the heat  
4        sink to limit the compression applied to the layer of thermally conductive material  
5        by the cured layer of cure shrinkable adhesive.

1        3.    The circuit board assembly of claim 2, wherein  
2        the outer surface of the substrate is flat, and  
3        the compression limiting structure extends inward as a portion of the heat  
4        sink to contact the outer surface of the substrate.

1        4.    The circuit board assembly of claim 2, wherein  
2        the inner surface of the heat sink is flat, and  
3        the compression limiting structure extends outward as a portion of the  
4        substrate to contact the inner surface of the heat sink.

1        5.    The circuit board assembly of claim 2, wherein  
2        the cured layer of cure shrinkable adhesive is shaped as a rectangle  
3        having a rectangular aperture,  
4        the circuit chip is disposed within the rectangular aperture, and  
5        the compression limiting structure includes a ridge extending around the  
6        cured layer of cure shrinkable adhesive.

1        6.    The circuit board assembly of claim 2, wherein  
2        the cured layer of cure shrinkable adhesive is shaped as a rectangle  
3        having a rectangular aperture,  
4        the compression limiting structure includes a ridge extending within the  
5        rectangular aperture of the cured layer of cure shrinkable adhesive, and  
6        the circuit chip disposed within the ridge extending within the rectangular  
7        aperture of the cured layer of cure shrinkable adhesive.

1       7.     The circuit board assembly of claim 2, wherein  
2             the cured layer of cure shrinkable adhesive is divided into a plurality of  
3       spaced apart pads extending around the circuit chip, and  
4             the compression limiting structure includes a plurality of ridges extending  
5       radially outward between adjacent pads in the plurality of spaced apart pads.

1       8.     The circuit board assembly of claim 2, wherein  
2             the cured layer of cure shrinkable adhesive is divided into a pair of  
3       rectangular pads extending along adjacent opposite ends of the heat sink, and  
4             the compression limiting structure includes a ridge extending adjacent  
5       each of the rectangular pads.

1       9.     The circuit board assembly of claim 1, wherein  
2             the outer surface of the substrate and the inner surface of the heat sink  
3       are both flat,  
4             the cured layer of cure shrinkable adhesive is shaped as a rectangle  
5       having a rectangular aperture, and  
6             the circuit chip is disposed within the rectangular aperture.

1       10.    The circuit board assembly of claim 1, wherein  
2             the outer surface of the substrate and the inner surface of the heat sink  
3       are both flat, and  
4             the cured layer of cure shrinkable adhesive is divided into a plurality of  
5       spaced apart pads extending around the circuit chip.

1       11.    The circuit board assembly of claim 1, wherein  
2             the outer surface of the substrate and the inner surface of the heat sink  
3       are both flat, and  
4             the cured layer of cure shrinkable adhesive is divided into a pair of

5 rectangular pads extending along adjacent opposite ends of the heat sink.

1 12. A heat sink for attachment to a substrate including a flat annular outer  
2 surface extending around a circuit chip, wherein the heat sink has an inner  
3 surface comprising:

4 a flat central portion for application of a layer of thermally conductive  
5 material,

6 a flat annular portion extending around the flat central portion of the inner  
7 surface of the heat sink for application of a cured layer of cure shrinkable  
8 material, and

9 a compression limiting structure extending inward from the flat annular  
10 portion for limiting compression of the thermally conductive material during curing  
11 of the cure shrinkable material.

1 13. The heat sink of claim 12, wherein the compression limiting structure  
2 includes a ridge extending around an inner edge of the flat annular portion of the  
3 inner surface of the heat sink.

1 14. The heat sink of claim 12, wherein the compression limiting structure  
2 includes a ridge extending around an outer edge of the flat annular portion of the  
3 inner surface of the heat sink.

1 15. The heat sink of claim 12, wherein the compression limiting structure  
2 includes a plurality of ridges extending radially along the flat annular portion of  
3 the inner surface of the heat sink.

1 16. The heat sink of claim 12, wherein the compression limiting structure  
2 includes a pair of parallel ridges extending along opposite sides of the flat central  
3 portion of the inner surface of the heat sink.

1 17. A substrate for attachment to a circuit chip, to a circuit board, and to a heat  
2 sink, including a flat annular inner surface extending around the circuit chip,  
3 wherein the substrate comprises:

4 an inner surface;

5 a plurality of contact terminals for connection to contact surfaces of a  
6 circuit board extending adjacent the inner surface of the substrate; and

7 an outer surface including a central portion having a plurality of contact  
8 surfaces for attachment to contact terminals of a circuit chip, wherein the contact  
9 surfaces of the outer surface of the substrate are individually electrically  
10 connected to contact terminals within the plurality of contact terminals, a flat  
11 annular portion extending around the central portion of the outer surface of the  
12 substrate for attachment to a cure shrinkable adhesive, and a compression  
13 limiting structure extending outward from the flat annular portion for limiting  
14 shrinkage of the cure shrinkable adhesive during curing.

1 18. The substrate of claim 17, wherein the compression limiting structure  
2 includes a ridge extending around an inner edge of the flat annular portion of the  
3 outer surface of the substrate.

1 19. The substrate of claim 17, wherein the compression limiting structure  
2 includes a ridge extending around an outer edge of the flat annular portion of the  
3 outer surface of the substrate.

1 20. The substrate of claim 17, wherein the compression limiting structure  
2 includes a plurality of ridges extending radially along the flat annular portion of  
3 the outer surface of the substrate.

1       21.   A circuit board assembly comprising:  
2           a circuit board including a plurality of conductive circuit traces extending  
3       from a plurality of contact surfaces;  
4           a plurality of substrates, wherein each substrate within the plurality of  
5       substrates has a plurality of contact terminals, individually connected to the  
6       contact surfaces of the circuit board by solidifying molten solder, an outer surface  
7       facing away from the circuit board, and a plurality of contact surfaces, extending  
8       along the outer surface of the substrate, individually electrically connected within  
9       the substrate to the plurality of contact terminals of the substrate;  
10          a circuit chip extending adjacent a central portion of the outer surface of  
11       each substrate within the plurality of substrates, wherein the central portion of the  
12       outer surface of the substrate is surrounded by an annular portion of the outer  
13       surface of the substrate, wherein the circuit chip has a plurality of contact  
14       terminals, individually connected to the contact surfaces of the substrate by  
15       solidifying molten solder, and an external surface;  
16          a heat sink extending outwardly from the circuit chip and from each  
17       substrate within the plurality of substrates, wherein the heat sink includes an  
18       inner surface having a central portion extending adjacent the outer surface of the  
19       circuit chip and an annular portion extending outward from the central portion;  
20          a layer of thermally conductive material extending between the external  
21       surface of the circuit chip and the central portion of the inner surface of the heat  
22       sink; and  
23          a cured layer of cure shrinkable adhesive extending between the annular  
24       portion of the outer surface of the substrate and the annular portion of the inner  
25       surface of the heat sink to hold the heat sink in place over the substrate and to  
26       hold the layer of thermally conductive material in compression.

1 22. The circuit board assembly of claim 21, additionally comprising a  
2 compression limiting structure extending between the annular portion of the outer  
3 surface of each substrate within the plurality of substrates and the annular  
4 portion of the inner surface of the heat sink attached to the substrate to limit the  
5 compression applied to the layer of thermally conductive material by the cured  
6 layer of cure shrinkable adhesive.

1 23. The circuit board assembly of claim 22, wherein  
2 the outer surface of the substrate is flat, and  
3 the compression limiting structure extends inward as a portion of the heat  
4 sink to contact the outer surface of the substrate.

1 24. The circuit board assembly of claim 22, wherein  
2 the inner surface of the heat sink is flat, and  
3 the compression limiting structure extends outward as a portion of the  
4 substrate to contact the inner surface of the heat sink.

1 25. A method for attaching a heat sink to a substrate having an annular outer  
2 surface extending around a circuit chip fastened to the substrate and extending  
3 outward from the annular outer surface of the substrate, wherein the substrate is  
4 additionally attached to a circuit board, and wherein the method comprises steps  
5 of:  
6 applying a layer of thermally conductive material to a central portion of an  
7 inner surface of the heat sink;  
8 applying a layer of cure shrinkable adhesive to an annular portion of the  
9 inner surface of the heat sink, wherein the annular portion of the inner surface of  
10 the heat sink extends around the central portion of the inner surface of the heat  
11 sink;  
12 placing the heat sink on the substrate with the thermally conductive  
13 material extending along an outer surface of the circuit chip, and with the cure

14 shrinkable adhesive extending along the annular outer surface of the substrate;  
15 and  
16 curing the layer of cure shrinkable adhesive.

1 26. The method of claim 25, wherein the layer of cure shrinkable adhesive is  
2 shaped as a rectangle having a central rectangular aperture.

1 27. The method of claim 26, wherein the layer of cure shrinkable adhesive is  
2 applied to extend around a ridge extending inward from the annular portion of the  
3 inner surface of the heat sink to limit shrinkage of the cure shrinkable adhesive  
4 during curing.

1 28. The method of claim 26, wherein the layer of cure shrinkable adhesive is  
2 applied to extend within a ridge extending inward from the annular portion of the  
3 inner surface of the heat sink to limit shrinkage of the cure shrinkable adhesive  
4 during curing.

1 29. The method of claim 26, wherein the layer of cure shrinkable adhesive is  
2 applied to extend, after the heat sink is placed on the substrate, around a ridge  
3 extending outward from the annular portion of the outer surface of the substrate  
4 to limit shrinkage of the cure shrinkable adhesive during curing.

1 30. The method of claim 26, wherein the layer of cure shrinkable adhesive is  
2 applied to extend, after the heat sink is placed on the substrate, within a ridge  
3 extending outward from the annular portion of the outer surface of the substrate  
4 to limit shrinkage of the cure shrinkable adhesive during curing.

1 32. The method of claim 25, wherein the layer of cure shrinkable adhesive is  
2 applied as a plurality of spaced apart pads.

1 33. The method of claim 32, wherein the spaced apart pads are individually  
2 placed on the annular portion of the inner surface of the heat sink between ridges  
3 extending inward from the inner surface of the heat sink to limit shrinkage of the  
4 cure shrinkable adhesive during curing.

1 34. The method of claim 32, wherein the spaced apart pads are individually  
2 placed on the annular portion of the inner surface of the heat sink to extend, after  
3 the heat sink is placed on the substrate, between ridges extending outward from  
4 the outer surface of the substrate to limit shrinkage of the cure shrinkable  
5 adhesive during curing.

1 35. The method of claim 25, wherein the layer of cure shrinkable adhesive is  
2 applied to opposite ends of the annular portion of the inner surface of the heat  
3 sink.

1 36. The method of claim 35, wherein each of the rectangular pads is applied to  
2 extend adjacent a ridge extending inward from the inner surface of the heat sink  
3 to limit shrinkage of the cure shrinkable adhesive during curing.

1 37. The method of claim 36, wherein each of the rectangular pads is applied to  
2 extend, after the heat sink is placed on the substrate, adjacent a ridge extending  
3 outward from the outer surface of substrate to limit shrinkage of the cure  
4 shrinkable adhesive during curing.